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Review

A review of the validity of malnutrition screening tools used in older adults in community and healthcare settings – A MaNuEL study

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SUMMARY

Background: Older adults are at increased risk of malnutrition compared to their younger counterparts. Malnutrition screening should be conducted using a valid malnutrition screening tool. An aim of the Healthy Diet for a Healthy Life (HDHL) Joint Programming Initiative (JPI) 'Malnutrition in the Elderly Knowledge Hub' (MaNuEL) was to review the reported validity of existing malnutrition screening tools used in older adults.

Methods: A literature search was conducted to identify validation studies of malnutrition screening tools in older populations in community, rehabilitation, residential care and hospital settings. A database of screening tools was created containing information on how each tool was validated.

Results: Seventy-four articles containing 119 validation studies of 34 malnutrition screening tools used in older adults were identified across the settings. Twenty-three of these tools were designed for older adults. Sensitivity and specificity ranged from 6 to 100% and 12–100% respectively. Seventeen different reference standards were used in criterion validation studies. Acceptable reference standards were used in 68 studies; 38 compared the tool against the Mini Nutritional Assessment-Full Form (MNA-FF), 16 used clinical assessment by a nutrition-trained professional and 14 used the Subjective Global Assessment (SGA). Twenty-five studies used inappropriate reference standards. Predictive validity was measured in 14 studies and was weak across all settings.

Conclusions: Validation results differed significantly between tools, and also between studies using the same tool in different settings. Many studies have not been appropriately conducted, leaving the true validity of some tools unclear. Certain tools appear to be more valid for use in specific settings.

Introduction

The world's population is ageing. In Europe, it is estimated that 34% of the population will be aged over 60 years by 2050 [1]. Ageing increases our vulnerability to many diseases, for example, cardiovascular disease and certain cancers [2]. However, it is universally acknowledged that optimal nutritional status in ageing mediates

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both the maintenance of health and the progression of disease [3]. Protein energy malnutrition (PEM), a state resulting from lack of uptake or intake of nutrition leading to altered body composition (hereafter referred to as malnutrition) [4], is of particular concern in older adults due to its associations with increased morbidity, mortality and prolonged hospital stay [5]. A large, retrospective pooled analysis of previous datasets estimated that 5% of community-dwelling older adults, 50% of those in rehabilitation, 20% in residential care and 40% in hospital are malnourished [6]; however, prevalence rates vary significantly between studies. This variability relates predominantly to the use of different assessment methods or definitions of malnutrition [7–10]. As the population of older adults rises, the absolute number of malnourished older adults will increase. Provided identification of malnutrition risk is followed by appropriate intervention, it has been suggested that early identification using a valid malnutrition screening tool is associated with better nutritional care and lower malnutrition incidence in the clinical setting [11].

The Healthy Diet for a Healthy Life (HDHL) Joint Programming Initiative (JPI) Malnutrition in the Elderly Knowledge Hub (MaNuEL) project is a collaborative initiative between six European countries and New Zealand which aims to extend scientific knowledge and strengthen evidence-based practise in the management of malnutrition in older adults [12]. One objective of MaNuEL is to review malnutrition screening tools used in older adults. The purpose of this narrative review is to examine the reported validity of malnutrition screening tools in older populations in different settings, including the community, rehabilitation, residential care and hospitals, and to draw conclusions as to which tools are more valid for use within each setting for this population group.

What is malnutrition screening?

Malnutrition screening is a quick and easy procedure using a valid malnutrition screening tool, designed to identify those who are malnourished or at risk of malnutrition and may benefit from nutritional intervention from a registered dietitian or expert clinician [13]. Early identification of those at risk of becoming malnourished is particularly important in older, multi-morbid adults [14].

Malnutrition screening is often confused with the term nutritional assessment, which is an in-depth, specific and detailed evaluation of nutritional status [15]. Moreover, some tools which are used for malnutrition screening were originally designed for 'nutritional' screening, e.g. screening for poor dietary intake. Terminology is used interchangeably in the literature and in clinical practise [13]. Understanding the differences between the terms used is pivotal to ensure best clinical practise in the management of malnutrition, and could diminish some of the reported barriers to screening, such as lack of time and inadequate nutrition knowledge [16]. Malnutrition screening tools are generally of questionnaire format, addressing risk factors for malnutrition (e.g. poor appetite or functional limitations), and indicators of malnutrition (e.g. recent involuntary weight loss) [15], and are most often administered by staff other than dietitians, such as nursing staff.

What are the benefits of malnutrition screening in older adults?

Effective malnutrition screening can identify older adults who are malnourished or at risk of malnutrition and is considered the first step in maintaining or restoring nutritional status [15]. Early identification of undernutrition can have a positive effect on other clinical outcomes, such as improvement in physical function and reduced length of hospital stay [15]. Visual identification of malnutrition risk may not be efficient, as clinical impression alone without training and use of specific criteria underdiagnosed risk of malnutrition in geriatric patients when compared to using a valid malnutrition screening tool [17]. It is, therefore, evident that effective screening procedures should be put in place to identify not only those who are already malnourished, but also those who are at higher risk of developing the condition [18]. Despite agreement on the importance of malnutrition screening, one large, European cross-sectional study found that less than half of hospital wards across Europe routinely screen for risk of malnutrition on admission [19].

The importance of validity of malnutrition screening tools

The term validation refers to assessing whether or not the tool measures/detects what it is intended to measure/detect. Measuring and reporting the validity of a screening tool in the population for which it is intended is important to ensure the tool is fit for purpose [5]. The different types of validity are defined in Table 1.

Valid tools ensure accurate identification of those at risk of malnutrition and facilitate appropriate referral to a dietitian [5]. Validity is most often measured by sensitivity (i.e. the percentage of individuals at risk of malnutrition correctly identified by the tool) and specificity (i.e. the percentage of well-nourished individuals correctly identified by the tool) compared to a gold standard reference (criterion validity) [20]. Validation is a different method of evaluation than reliability, which is the measure of agreement between the results of the malnutrition screening tool when more than one user applies it to the same subject (Table 1) [21].

Considerations for critiquing validation results of malnutrition screening tools

It is not enough to conclude that a malnutrition screening tool is valid for use based purely on sensitivity and specificity results

Table 1
Definitions of different types of validity and reliability [20–22].

Validity	Indicates whether a tool measures what it is supposed to measure. Important in the development and ongoing evaluation of the developed tool. New validation studies are needed for use of the tool in different populations.
Content Validity	Explores the relevance and completeness of a tool's content. Usually assessed by a group of experts who consider the tool's suitability in relation to its intended use and purpose. Relates primarily to the tool's construction.
Construct Validity	Assesses the extent to which a measure performs in accordance with theoretical expectations. Requires specification of the expected relationship between the tool's outcome with variables not used to construct the tool, for example, anthropometric and/or laboratory measures are compared to the outcome of the malnutrition screening tool.
Criterion Validity	Comparison of the tool's identification of risk with that obtained using the gold standard procedure. Good agreement is expected if the tool performs well. Tool performance is generally summarised by its sensitivity and specificity.
Predictive Validity	Ability of the malnutrition screening tool to predict specified outcomes (e.g. mortality, length of hospital stay).
Reliability	The measure of agreement between the results of the malnutrition screening tool when more than one user applies it to the same subject.

Good	Fair	Poor
Sensitivity AND Specificity >80%	Sensitivity OR Specificity >80%, but both >50%	Sensitivity OR Specificity <50%
Area Under Curve >0.8	Area Under Curve 0.6-0.8	Area Under Curve <0.6
Correlation Co-efficient >0.75	Correlation Co-efficient 0.40-0.75	Correlation Co-efficient <0.40
Kappa >0.6	Kappa 0.4-0.6	Kappa <0.4
Odds Ratio/Hazard Ratio >3	Odds Ratio/Hazard Ratio 2-3	Odds Ratio/Hazard Ratio <2

Fig. 1. Cut-off Points for Rating Validation Results of Malnutrition Screening Tools (adapted from de van der Schueren et al., 2014) [31].

alone, as there is currently no agreed gold standard to assess malnutrition. Therefore, criterion validity cannot be accurately assessed. Clinical assessment by a nutritionally trained professional (e.g. a dietitian), the Subjective Global Assessment (SGA) and the full form of the Mini Nutritional Assessment (MNA-FF), are suggested reference standards for validation studies of malnutrition screening tools that could act as 'semi-gold' reference standards, as all standards assess body composition and changes to body composition over time [13]. However, many criterion validation studies have inappropriately used other screening tools [23,24], biochemical measures (e.g. serum albumin level and/or lymphocyte count) [25,26] or a combined score of several screening and assessment tools [27] as the reference standard. Validating one screening tool against another screening tool cannot give an accurate representation of the tool's true validity, as they are not designed to diagnose the condition under investigation i.e. malnutrition. Biochemical measurements have been consistently shown to be unreliable indicators of nutritional status in older adults [28,29]. Moreover, they are costly and time-consuming, contradicting the principles of good screening practise set out by Wilson and Jungner, which state that screening should be a quick and simple procedure [30]. The use of a combined index of screening tools, which includes the tool under investigation, introduces incorporation bias as the index includes the tool itself, hence increasing sensitivity. Studies using such reference standards should be interpreted with caution.

Correct and consistent interpretation of the validation results is important. A systematic review of the validity of malnutrition screening tools in nursing homes has defined specific cut-offs for determining good versus poor validation results (Fig. 1).

Methods

Literature search strategy

Two qualified nutrition/dietetics researchers performed targeted electronic searches between the months of October 2016 and April 2017 in the following databases; PubMed Central, CINAHL Plus, Science Direct and SCOPUS. Search engines used included Google and Google Scholar. No year limits were applied to any search engine or database search. Limits were applied in all databases to include only journal articles, books/eBooks and book chapters, and only those written in the English language. Key search terms used included "malnutrition", "protein-energy malnutrition", "undernutrition", "nutrition"; "over 65s", "elderly", "older adults"; "screening tools", "nutritional screening", "malnutrition screening"; "hospital", "primary care", "nursing homes", "residential-care", "institutionalised", "community-dwelling", "community care"; "validity", "validation" as well as known individual nutritional/malnutrition screening tools. Reference lists were also checked for relevant citations.

Database creation

A database was created containing information on all malnutrition screening tool validation studies identified from the literature search. This included tools designed for screening for risk of malnutrition, and tools which were designed for screening for general nutritional status but had evidence of validity for malnutrition screening.

Inclusion criteria

- Studies reporting validity of a malnutrition screening tool in community, rehabilitation, residential care and hospital populations with a mean age of 65y or greater.
- Tools which report screening for risk of malnutrition, protein-energy malnutrition and/or undernutrition.
- Tools which were developed in and or/validated in European and non-European populations.
- Studies deemed both 'appropriately designed' using a semi-gold standard reference and 'inappropriately designed' were included in the review to allow for a complete critical appraisal of the literature.

Exclusion criteria

- Validation studies of malnutrition screening tools in the hospital setting that focus on an older group with a specific clinical condition (e.g. cancer, coronary heart disease).
- Validation studies of nutritional assessment tools.

Data recorded included type of validation, validation results, reference standard used, population size and setting. The database also contained information such as the parameters of the tool (i.e. what the tool asks/measures) and its practicability (e.g. time-taken, cost). The database was circulated to experts in the field of malnutrition within MaNuEL and across the world for review, to ensure no tool had been omitted and that all relevant information on each tool was included in the database.

Results

Overall findings

Seventy-four articles containing 119 validation studies were identified across four settings; the community, rehabilitation, residential care and hospital (Fig. 2). Twenty-three articles contained more than one validation study (e.g. assessed both criterion and predictive validity, or used more than one reference standard). The majority of validation studies were conducted in the hospital setting (n = 56), followed by the community setting (n = 36), with fewer studies in residential care (n = 20) and rehabilitation (n = 7).

Thirty-four malnutrition screening tools have been tested for validity in older adults. Of these, 23 were designed specifically for use in this population. Of the 11 tools not designed for older adults, but validated for use within this population, three had an adjustment for older adults (e.g. Body Mass Index (BMI) cut-off of 20 kg/m^2 instead of 18.5 kg/m^2 if over 70 years).

Overall, the most frequently validated tools, across all settings, were the MNA-SF version 1 (22 studies) and MUST (15 studies). In each setting, the tool most often validated was the MNA-SF version 1 in the hospital setting (9 studies), MNA-SF version 1 in the community setting (8 studies), MUST in residential care (5 studies) and the Nutritional Form for the Elderly (NUFFE) in rehabilitation (2 studies).

Quality of study design

Participation size ranged from 20 to 6033 participants. Ninety-three studies assessed criterion validity, 14 assessed predictive validity, 7 assessed construct validity and 5 studies assessed reliability.

Of the 93 studies that assessed criterion validity; 38 used the MNA-FF as the validation reference standard, 16 used clinical assessment by a nutrition-trained professional and 14 used the SGA. Thus, in total, 68 studies validated against a reference considered 'semi-gold-standard'. Eight studies used another screening tool [e.g. MUST, Nutrition Risk Screening-2002 (NRS-2002)], eight studies used a combined index of tools, seven studies used various definitions of malnutrition, one study used albumin and one study used results from 16 randomised control trials (RCTs), none of which is considered an appropriate reference standard. Eleven of these studies validated a malnutrition screening tool against a nutritional assessment tool that contained all components of the screening tool (i.e. the MNA-SF validated

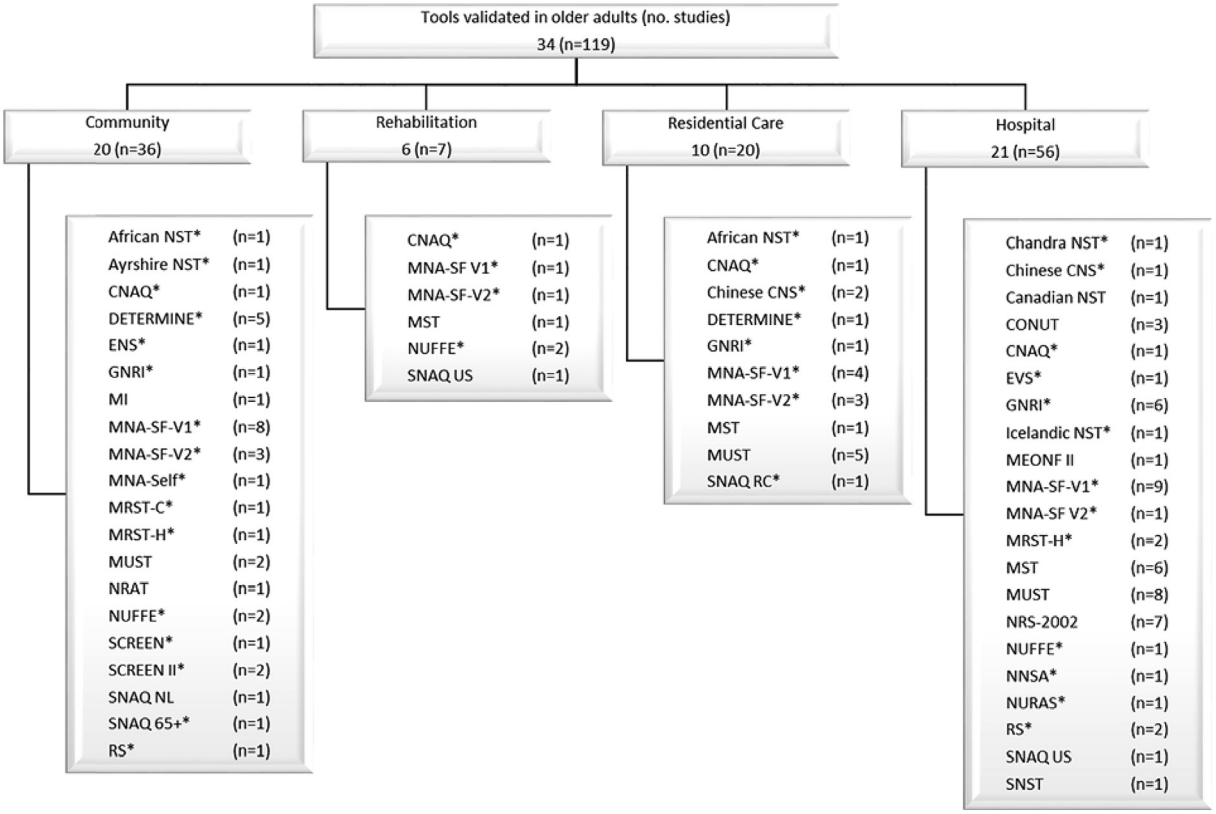

Fig. 2. Malnutrition screening tools validated in older adults (no. of studies) by healthcare setting. *Designed for older adults. CNAQ: Council on Nutrition Appetite Questionnaire, CNS: Chinese Nutritional Screen, CONUT: Controlling Nutritional Status, DETERMINE: Determine Your Health Checklist, ENS: Elderly Nutrition Screening, EVS: Eating Validation Scheme, GNRI: Geriatric Nutritional Risk Index, MEONF II: Minimal Eating Observation Form Version Two, MI: Maastricht Index, MNA–SF–V1: Mini Nutritional Assessment Short Form Version One, MNA–SF–V2: Mini Nutritional Assessment Short Form Version Two, NST: Nutritional Screening Tool, MNA-Self: Mini Nutritional Assessment Self-Assessment, MRST-C: Malnutrition Risk Screening Tool - Community, MRST-H: Malnutrition Risk Screening Tool - Hospital, MST: Malnutrition Screening Tool, MUST: Malnutrition Universal Screening Tool, NNSA: Nursing Nutrition Screening Assessment, NRAT: Nutritional Risk Assessment Tool, NRS-2002: Nutrition Risk Screening 2002, NUFFE: Nutritional Form for the Elderly, NURAS: Nutritional Risk Assessment Scale, RS: Risk Screen, SCREEN: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire, SCREEN II: Seniors in the Community - Risk Evaluation for Eating and Nutrition Questionnaire Version Two, SNAQ NL: Short Nutritional Assessment Questionnaire (the Netherlands Tool), SNAQ^{RC}: Short Nutritional Assessment Questionnaire - Residential Care, SNAQ-US: Simplified Nutritional Appetite Questionnaire (the United States Tool), SNST: Simple Nutritional Screening Tool.

against MNA-FF); this standard is not considered appropriate as incorporation bias is introduced.

Validation results

Overall, sensitivity and specificity ranged from 6 to 100% and 12–100% respectively in criterion validation studies across all settings. Predictive validity was weak in most studies, with low hazard ratios, odds ratios and non-significant p-values commonly reported.

The validation results of tools validated in more than two studies are discussed below. These are categorised as follows: 1) malnutrition screening tools originally designed for use with older adults and, 2) malnutrition screening tools not originally designed for older adults, but which have been validated in populations over 65 years.

Malnutrition screening tools validated in older adults

Malnutrition screening tools originally designed for older adults

Mini Nutritional Assessment short-form (MNA-SF version 1)

The MNA-SF version 1 consists of six questions taken directly from the MNA-FF, a nutritional assessment tool [32]. It has been validated in all settings (Table 2). Criterion validity results appear to be promising in the community, with sensitivity ranging from 81 to 100% and specificity ranging from 82 to 100% [32–37]. However, all studies in this setting have used the MNA-FF as the reference standard; thus, incorporation bias is present. Criterion validity has also been studied in residential care; two studies reported sensitivities of 86% [36] and 100% [33], and specificities of 92% [36] and 95% [33]. Again, these studies validated the tool against the MNA-FF, leaving its validation in this setting questionable.

Validation studies in the hospital setting are more plentiful, and provide evidence of criterion validity (Table 2) [27,38–41]. MNA-SF values for sensitivity range from 95 to 100% and for specificity from 41 to 79% in the hospital setting [27,38–40]; however, only one study used an accepted reference standard (SGA) [39]. This study yielded good sensitivity (100%) but fair specificity (53%), suggesting that the MNA-SF may over-estimate malnutrition risk in the hospital setting. As this tool is widely recommended for use with older adults [15], exploring the validity of the MNA-SF further (in all settings) using more appropriate criterion validation techniques is warranted.

Mini Nutritional Assessment-short form version 2 (MNA-SF version 2)

The MNA-SF version 1 was revised and revalidated in 2009, and includes calf circumference instead of BMI for cases in which measurement of height and weight is difficult, such as with bedridden older patients [42]. Criterion validity of the revised version, also referred to as MNA-SF version 2, has also been tested in all settings (Table 2) [36,42–45]. All studies used the MNA-FF as the reference standard, thus, incorporation bias is present. Three studies reported sensitivity and specificity, which were above 80% in each study [36,46]. Kappa values are reported in most studies, all of which are 0.6 or above [43–45], which is considered the cut-off for good validation results [31]. It has been suggested that the MNA-SF version 2 should only be used in cases where body weight and body height cannot be measured accurately, as it has been found to be less sensitive and specific than the original MNA-SF [43]. As all validation studies of the MNA-SF version 2 have been against its full version, further research using an appropriate semi-gold standard is needed to agree on its validity in all settings.

Short Nutritional Assessment Questionnaire (SNAQ)

The original Short Nutritional Assessment Questionnaire (SNAQ-NL), not to be confused with the US screening tool (Simplified Nutritional Assessment Questionnaire, SNAQ-US) [48] was designed to be a quick and simple malnutrition screening tool for hospitalised adult patients, and is the screening tool recommended by the Dutch Malnutrition Steering Group for use in the Netherlands [49]. It has been validated in community-dwelling adults with a mean age >65y against a definition of malnutrition (BMI <20 kg/m^2 or unintentional weight loss of 5–10%) yielding poor validation results (sensitivity of 31% and specificity of 98%), suggesting that this version of SNAQ is not acceptable for use with older community-dwelling adults [50]. Following the successful introduction of the SNAQ-NL into clinical care in the Netherlands [51], a version specific to the older population living at home, SNAQ^{65+}, was developed and validated. Predictive validity was assessed for 6-year mortality (Hazard Ratio (HR) 2.46 for those in the 'at risk' of malnutrition group) [52]; however, no criterion validity was reported, making it difficult to describe the validity of this tool in community-dwelling older adults. As this is a relatively new screening tool, further validation studies could provide evidence for wider use of SNAQ^{65+}.

Another version of the SNAQ-NL is the SNAQ-Residential Care (SNAQ^{RC}) screening tool which was developed for use in residential care, and has evidence of good criterion validity (sensitivity 87%, specificity 82%) against clinical assessment by a trained dietitian [53]. However, as the reference standard included BMI, which is also used in the tool, incorporation bias is present. The SNAQ^{RC} is currently the only tool designed specifically for screening institutionalised older adults. More studies are needed to determine its validity in this setting. These may provide evidence on whether setting-specific tools are more effective in older populations [13].

Determine your Health Checklist (DETERMINE)

The Determine your Health Checklist (DETERMINE) was developed by the US Nutrition Screening Initiative (NSI) in the early 1990s, and is the first part of a two-step approach to screening and assessment of nutritional status in older adults living in the community [54]. Although it was originally designed for the purpose of screening for general nutritional status (i.e. a 'nutrition' screening tool), it has been validated as a malnutrition screening tool in the community. Predictive validity in this setting has been poor, as the Checklist was unable to predict mortality, hospitalisation or weight loss greater than 5% [55,56]. Criterion validity results in the community differ considerably, with sensitivities of 75% [57] and 91% [33], and specificities of 11% [33] and 54% [57] reported. However, like many validation studies discussed in this review, poor study design is apparent with DETERMINE, as only one study used an appropriate reference standard (the MNA-FF) for validation [33]. This study reported high sensitivity (91%), but low specificity (11%) in the community and residential care, suggesting the tool overestimates risk of malnutrition. This may be due to the tool having been designed to indicate more general risk of poor nutritional status (both over- and undernutrition) as opposed to risk of malnutrition. More studies using an acceptable semi-gold standard reference are needed to agree on whether this tool is a valid instrument for use in older adults.

Table 2
Validation Studies of the MNA-Short Form (both version 1 and version 2) According to Setting.

First author (Year)	Population	No. Participants	Validated against	Validation results	Type of validity
Screening Tool: MNA-SF Version 1					
Community					
Lilamand (2015) [37]	France	297	MNA-FF	Se 94.0% Sp 83.3% AUC 0.954	Criterion Validity
Kostka (2014) [36]	Poland	932	MNA-FF	Se 82.7% Sp 88.9%	Criterion Validity
Tsai (2013) [44]	Taiwan	2674	MNA-FF	k = 0.7	Criterion Validity
De La Montana (2011) [35]	Spain	728	MNA-FF	Se 81.4% Sp 92.7% r = 0.916	Criterion Validity
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.6	Criterion Validity
Wikby (2008) [34]	Sweden	127	MNA-FF	Se 89.0% Sp 82.0% k = 0.4	Criterion Validity
Charlton (2007) [33]	South Africa	220	MNA-FF	Se 100% Sp 94.6% PPV 16.3% NPV 62.6% r = 0.811	Criterion Validity
Rubinstein (2001) [32]	France, Spain, New Mexico	881	MNA-FF	Se 97.9% Sp 100% AUC 0.961 r = 0.945	Criterion Validity
Rehabilitation					
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.6	Criterion Validity
Residential Care					
Kostka (2014) [36]	Poland	859	MNA-FF	Se 85.7% Sp 91.6%	Criterion Validity
Garcia-Meseguer (2013) [43]	Spain	895	MNA-FF	k = 0.7	Criterion Validity
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.8	Criterion Validity
Charlton (2007) [33]	South Africa	220	MNA-FF	Se 100% Sp 94.6% PPV 16.3% NPV 62.6% r = 0.811	Criterion Validity
Hospital					
Christner (2016) [41]	Germany	201	MNA-FF	k = 0.7	Criterion Validity
Baek (2015) [40]	Korea	141	Combined Index of 5 tools	Se 100% Sp 49.4% k = 0.5	Criterion Validity
Zhou (2015) [25]	China	142	Clinical Assessment	p < 0.05	Construct Validity
Rasheed (2013) [23]	Wales	149	MUST	Mortality HR p = 0.009 LOS p = 0.037	Predictive Validity
Young (2013) [39]	Australia	134	SGA	Se 100% Sp 52.8% PPV 64.6% NPV 100% AUC 0.950	Criterion Validity
Young (2013) [39]	Australia	134	MNA-FF	Se 95.6% Sp 79.1% PPV 90.5% NPV 89.5% AUC 0.960	Criterion Validity
Poulia (2012) [27]	Greece	248	Combined Index of 6 screening tools	Se 98.1% Sp 50.0% PPV 79.9% NPV 93.2% k = 0.6	Criterion Validity
Neelemaat (2011) [38]	Netherlands	101	BMI Unintentional Weight loss	Se 100% Sp 41.0% PPV 42.0% NPV 100%	Criterion Validity
Kuzuya (2005) [47]	Japan	161	Clinical Assessment	p < 0.05	Construct Validity
Screening Tool: MNA-SF Version 2					
Community					
Kostka (2014) [36]	Poland	932	MNA-FF	Se 81.4% Sp 87.1%	Criterion Validity
Tsai (2013) [44]	Taiwan	2674	MNA-FF	k = 0.7	Criterion Validity
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.6	Criterion Validity
Rehabilitation					
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.6	Criterion Validity
Residential Care					
Kostka (2014) [36]	Poland	859	MNA-FF	Se 86.3% Sp 85.0%	Criterion Validity
Garcia-Meseguer (2013) [43]	Spain	895	MNA-FF	k = 0.6	Criterion Validity
Kaiser (2011) [45]	Germany	657	MNA-FF	k = 0.7	Criterion Validity
Hospital					
Kaiser (2009) [42]	Various	2032	MNA-FF	Se 89.0% Sp 82.0%	Criterion Validity

AUC: Area Under the Curve, BMI: Body Mass Index, HR: Hazard Ratio, k: Kappa Value, LOS: Length of Stay, MNA-FF: Mini Nutritional Assessment Full Form, MNA-SF: Mini Nutritional Assessment Short Form, MUST: Malnutrition Universal Screening Tool, NPV: Negative Predictive Value, p: p-value, PPV: Positive Predictive Value, r: Correlation Co-efficient, Se: Sensitivity, SGA: Subjective Global Assessment, Sp: Specificity.

Nutritional Form for the elderly (NUFFE)

The NUFFE was designed with the purpose of obtaining a simple, clinically useful tool to screen for undernutrition in older rehabilitation patients in Sweden [58], and has since been validated in other settings, including the community and hospital [59,60]. Its original validation study design is questionable as criterion and predictive validity were assessed against BMI, weight index and albumin levels, all of which have been considered unreliable measures of nutritional status in older adults [28,58,61]. A subsequent study in the rehabilitation setting reported that the NUFFE could identify malnutrition as effectively as clinical assessment by a trained nutrition professional ($p < 0.05$) [62]. One study examined criterion validity in a geriatric hospital ward against the MNA-FF, resulting in good correlation ($r = 0.74$) and reliability (Cronbach's co-efficient 0.77) [63]. It is worth noting that all validation studies identified, with the exception of one Chinese study, were carried out by the same researcher, which may be considered a form of observer bias. Although the reported results are encouraging, more evidence on sensitivity and specificity is needed to strengthen the criterion validity for NUFFE in all settings.

Geriatric Nutritional Risk Index (GNRI)

The Geriatric Nutritional Risk Index (GNRI) was introduced as an age-specific screening tool which classifies hospitalised patients according to risk of complications related to illnesses often

associated with malnutrition [64]. It has been found to accurately predict morbidity and mortality in older hospitalised patients ($p < 0.05$) [64] and residents in long-term care ($p < 0.05$) [65]. Although the GNRI is designed for use in older adults, results from four criterion validation studies in hospitalised older adults vary greatly, with sensitivity ranging from of 66–95%, and specificity from 55 to 92% [27,40,66,67]. No study was carried out using an acceptable reference standard, leaving its true validity in this setting unknown. An author of one of these studies concluded that the GNRI is a "perfect tool" which can be used in different settings; however, this statement does not reflect the existing evidence [66].

One predictive validity study in the community setting found a 50% increased risk of hospitalisation with low GNRI score [68]. Screening tools that require laboratory measurements (as this one does) are unlikely to be suitable to screen for malnutrition risk in the community setting. It is likely, therefore, that the use of GNRI in this setting is limited [69]. Furthermore, no validation studies exist in older adults in rehabilitation.

Seniors in the community: Risk Evaluation for eating and Nutrition Questionnaire (SCREEN-II)

The Seniors in the Community: Risk Evaluation for Eating and Nutrition Questionnaire (SCREEN-II) was developed for older community-dwelling adults with the purpose of screening for general nutritional status, but has been validated as a malnutrition screening tool. It has demonstrated good validity in older community-dwelling Canadian [70,71] and New Zealand [72] populations. Criterion validity has been examined in these studies, all against clinical assessment by a trained dietitian. Reported sensitivity ranged from 84 to 90%, and specificity from 62 to 86% [70–72]. These are promising results for malnutrition screening in community-dwelling older adults. Validation studies are required if this tool is to be considered for use in other settings.

Malnutrition screening tools designed for adults that have been validated in older adults

Malnutrition Universal Screening Tool (MUST)

Although it is widely accepted by healthcare professionals that MUST is a practical tool for assessing malnutrition in the general adult population, its use in older adults across all settings remains uncertain [73–75]. Few studies have tested the validity of MUST in community-dwelling older adults, with the majority of studies focussing on its use in geriatric hospital wards and nursing homes (Table 3). One validation study in the community setting reported good sensitivity (100%) and specificity (98%) when validated against clinical assessment by a trained dietitian [76]. In residential care settings, MUST has been consistently found to be predictive of mortality ($p < 0.05$) [74,77]. Criterion validity studies have been appropriately designed in this setting, as MUST was validated against both the MNA-FF and the SGA in three studies. Good specificity was reported in two of these studies (87% and 98%) [73,78]; however, sensitivities were low (48% and 77%) [73,78]. Criterion validity studies in the hospital setting have used a number of reference standards, including the SGA [39] and MNA-FF [39], but also unsuitable standards such as the GNRI [67], MNA-SF [23] and a combined index of several screening tools [27,40]. One study used both the SGA and MNA-FF, reporting sensitivities of 68% and 87% and specificities of 86% and 93% [39], suggesting MUST may be a valid tool for use with geriatric hospitalised patients.

Malnutrition screening tool (MST)

Although it was not designed for older adults, the Malnutrition Screening Tool (MST) has been widely validated in hospitalised older patients in both Europe and Australia [38,39,81–83]. Studies have used different reference standards [including SGA, NRS-2002, MNA-FF or malnutrition (BMI <20 kg/m^2 or 5–10% weight loss over the previous six months)] [38,39,81–83]. Three studies have used a semi-gold standard reference, yielding good results; two against the SGA (sensitivities of 90% and 94% and specificities of 85% and

Table 3
Validation studies of the malnutrition universal screening tool (MUST) according to setting.

First author (Year)	Population	No. Participants	Validated against	Validation results	Type of validity
Community					
Leistra (2013) [50]	The Netherlands	2238	BMI or unintentional weight loss	Se 58.0% Sp 96.0%	Criterion Validity
Harris (2008) [76]	Wales	100	Clinical Assessment	Se 100% Sp 98.0% PPV 83.0% NPV 100%	Criterion Validity
Residential Care					
Donini (2016) [78]	Italy	246	MNA-FF	Se 48.0% Sp 98.0% HR 3.49 ($p = 0.01$) $k = 0.3$	Criterion Validity
Mountford (2016) [74]	England	205	12 week mortality	$p = 0.004$	Predictive Validity
Diekmann (2013) [77]	Germany	200	MNA-FF	$p = 0.001$ (6-month mortality) $p = 0.012$ (1 year mortality)	Predictive Validity
Isenring (2012) [73]	Australia	121	SGA	Se 68.6% Sp 96.7% $k = 0.9$	Criterion Validity
Isenring (2012) [73]	Australia	121	MNA-FF	Se 76.5% Sp 87.3% $k = 0.9$	Criterion Validity
Hospital					
Baek (2015) [40]	Korea	141	Combined Index of 5 screening tools	Se 80.6% Sp 98.7% PPV 98.0% NPV 86.7% $k = 0.6$ $p < 0.000$	Criterion Validity
Koren-Hakim (2015) [79]	Israel	215	N/A	No relationship found between MUST and LOS, mortality, readmission or complications	Predictive Validity
Tripathy (2015) [67]	India	111	GNRI	Se 96.5% Sp 72.3% PPV 80.9% NPV 94.4%	Criterion Validity
Rasheed (2013) [23]	Wales	149	MNA-SF	$k = 0.5$ Mortality HR $p = 0.013$ LOS $p = 0.195$	Predictive Validity
Young (2013) [39]	Australia	134	SGA	Se 87.1% Sp 86.1% PPV 84.4% NPV 88.6% AUC 0.890	Criterion Validity
Young (2013) [39]	Australia	134	MNA-FF	Se 67.8% Sp 93.0% PPV 95.3% NPV 58.0% AUC 0.820	Criterion Validity
Poulia (2012) [27]	Greece	248	Combined Index of 6 screening tools	Se 87.3% Sp 76.8% PPV 88.4% NPV 75.0% $k = 0.6$ $p = 0.000$	Criterion Validity
Stratton (2006) [80]	England	150	N/A	LOS $p = 0.02$ Mortality $p < 0.03$	Predictive Validity

AUC: Area Under the Curve, BMI: Body Mass Index, GNRI: Geriatric Nutrition Risk Index, HR: Hazard Ratio, k: Kappa Value, LOS: Length of Stay, MNA-FF: Mini Nutritional Assessment Full Form, MNA-SF: Mini Nutritional Assessment Short Form, MUST: Malnutrition Universal Screening Tool, NPV: Negative Predictive Value, p: p-value, PPV: Positive Predictive Value, Se: Sensitivity, SGA: Subjective Global Assessment, Sp: Specificity.

Table 4
Validation studies of the malnutrition screening tool (MST) according to setting.

First Author (Year)	Population	No. Participants	Validated Against	Validation Results	Type of Validity
Rehabilitation					
Marshall (2016) [84]	Australia	57	ICD-10-AM	Se 80.9% Sp 67.7%	Criterion Validity
Residential Care					
Isenring (2009) [85]	Australia	285	SGA	Se 83.6% Sp 65.6%	Criterion Validity
Hospital					
Bell (2013) [83]	Australia	100	ICD-10-AM	Se 73.0% Sp 55.0%	Criterion Validity
Young (2013) [39]	Australia	134	SGA	Se 90.3% Sp 84.7%	Criterion Validity
Young (2013) [39]	Australia	134	MNA-FF	Se 97.7% Sp 88.3%	Criterion Validity
Wu (2012) [82]	Australia	157	SGA	Se 94.0% Sp 89.0%	Criterion Validity
Neelemaat (2011) [38]	Netherlands	171	BMI Unintentional Weight Loss	Se 78.0% Sp 94.0%	Criterion Validity
Martins (2005) [81]	Portugal	207	NRS-2002	Se 58.5% Sp 84.6%	Criterion Validity

BMI: Body Mass Index, ICD-10-AM: International Classification of Diseases - 10th revision - Australian Modification, MNA-FF: Mini Nutritional Assessment Full Form, NRS-2002: Nutrition Risk Screen 2002, Se: Sensitivity, SGA: Subjective Global Assessment, Sp: Specificity.

89%) [39,82] and one against the MNA-FF (sensitivity 98% and specificity 88%) [39]. These results suggest that the MST is an appropriate tool for use in hospitalised older patients.

The MST has also been validated in older adults in rehabilitation (against the ICD-10-AM classification for malnutrition) [84] and in residential care (against the SGA) [85]; however, validation results were fair in these settings with high sensitivity (greater than 80%) but low specificity (less than 70%) in both studies. No studies have assessed validity of the MST in community-dwelling older adults (Table 4).

Nutritional risk screening (NRS-2002)

The NRS-2002 tool was originally developed for use in adults and is recommended for screening in the hospital setting by the European Society for Clinical Nutrition and Metabolism (ESPEN) [15]. Criterion validity has been assessed in geriatric hospitalised patients but results are inconclusive due to large variability in reported validation results (sensitivity ranging from 52 to 100%, specificity ranging from 6 to 95%) [25,27,40,41]. The one study that used an appropriate reference standard (both the MNA-FF and the SGA) reported good results (MNA: sensitivity 72%, specificity 95%; SGA: sensitivity 90%, specificity 83%) [39], suggesting that NRS-2002 may be a valid tool to use with older adults in the hospital setting and that the poor results observed in some studies result from validation against inappropriate reference standards. Nonetheless, further studies using appropriate reference standards would strengthen the evidence for its use, in particular, outside the hospital setting. Predictive validity was also assessed in the hospital setting in one study; however, no relationship between the NRS-2002 and post-operative complications, albumin level and length of stay (LOS) was observed [79].

Controlling Nutritional Status (CONUT)

The Controlling Nutritional Status (CONUT) screening tool differs from other malnutrition screening tools (which are primarily in questionnaire format) as it consists of three biochemical measures; serum albumin, total lymphocyte count and cholesterol [86]. It was designed and validated in a hospitalised adult population (mean age 66.8y) against clinical assessment by a trained physician, and achieved good validation results (sensitivity 92% and specificity 85%) [86]. Further validation studies have also been appropriately designed. One study used the MNA-FF as the reference standard, yielding fair results (sensitivity 43%, specificity 72%) [87]. Another study, using the SGA, reported good results (sensitivity 78%, specificity 89%) [88]. Nonetheless, the use of biochemical markers as a measure of nutritional status in older adults remains unclear [28,29], as it is difficult to establish whether abnormal levels are due to malnutrition itself, an underlying disease, or disease-associated inflammation. For this reason, the use of CONUT as a malnutrition screening tool remains controversial. Its use in community, rehabilitation and residential care settings has not been assessed.

Malnutrition risk screening tool (MRST)

The malnutrition risk screening tool (MRST) has been validated in older Malaysian populations, and consists of two versions; the MRST-community (MRST-C) and the MRST-hospital (MRST-H) [89,90]. Neither version of the tool appears valid for screening for risk of malnutrition in any population, with low sensitivity reported for both versions; sensitivity was 26% [90] and 56% [89] for the MRST-C, and ranged from 12 to 67% for the MRST-H [90–92]. Moreover, study design was poor in all validation studies, with biochemical measures, a 'global indicator of malnutrition' (combination of BMI, biochemical measures and SGA) and functional assessment used as reference standards. Further studies using appropriate reference standards are required before MRST is recommended as a malnutrition screening tool for older adults.

Other malnutrition screening tools validated in older adults

A number of other malnutrition screening tools with evidence of validation in older adults were identified. Several were not designed for older adults. The majority have just one validation study in an older population. A summary of these validation studies is shown in Table 5. Of the tools designed for older adults, the African Nutrition Screening Tool (African NST) and the MNA-self assessment (MNA-Self) were the only tools reporting appropriate validation study design and good validation results.

Of the tools not originally designed for older adults, the Canadian NST appears the most valid with a sensitivity of 73% and specificity of 86% against the SGA [93]. It is important to note that these validation results need to be interpreted with caution, as each tool had only one validation study; therefore, conclusions on their suitability to screen for risk of malnutrition in older populations cannot be drawn at the current time.

Discussion

This review identified 48 malnutrition screening tools used in older adults; only 34 had been validated in this population. A further 14 tools lacked evidence of validity in those aged over 65 [110–122]. For the purpose of this review, we included tools designed to screen for malnutrition, and tools to screen for general poor nutritional status, that have been validated as malnutrition screening tools. We also included tools which were developed in

Table 5
Other malnutrition screening tools validated in older populations in less than three studies according to setting.

Screening Tool	First Author (Year)	Population	No. Participants	Validated Against	Validation Results	Type of Validity
Designed for Older Adults						
Community						
African NST	Charlton (2005) [94]	South Africa	283	MNA-FF	Se 87.5% Sp 95.0% NPV 99.5%	Criterion Validity
Ayrshire NST	Mackintosh (2001) [95]	UK	70	Agreement between nurse and dietitian	r = 0.73	Reliability
Council on Nutrition Appetite Questionnaire (CNAQ)	Wilson (2005) [96]	USA	352	AHSP	Cronbach's a = 0.74	Reliability
Elderly Nutrition Screening (ENS)	Laforest (2007) [97]	Canada	29	N/A	Volunteer and Dietitian k = 0.3 Volunteer and Volunteer k = 0.6	Reliability
MNA-SF (Self-Assessment)	Huhmann (2013) [24]	USA	463	MNA-SF	Se 99.0% Sp 98.0%	Criterion Validity
Rapid Screen (RS)	Visvanathan (2004) [26]	Australia	65	Clinical Assessment	Se 78.6% Sp 97.3%	Criterion Validity
Rehabilitation						
Council on Nutrition Appetite Questionnaire (CNAQ)	Yaxely (2015) [48]	Australia	185	MNA-FF	Se 54.0% Sp 81.0% PPV 83.0% NPV 51.0%	Criterion Validity
Residential Care						
African NST	Charlton (2005) [94]	South Africa	283	MNA-FF	Se 87.5% Sp 95.0% NPV 99.5%	Criterion Validity
Council on Nutrition Appetite Questionnaire (CNAQ)	Wilson (2005) [96]	USA	247	AHSP	Cronbach's a = 0.47	Reliability
Chinese Nutrition Screen (CNS)	Lok (2009) [98]	China	515	SGA	Se 60.9% Sp 72.9% PPV 25.8% NPV 92.3%	Criterion Validity
Chinese Nutrition Screen (CNS)	Woo (2005) [99]	China	867	Clinical Assessment	k = 0.5 PPV 60.0% NPV 90.0% AUC 0.79	Criterion Validity
Hospital						
Chandra NST	Azad (1999) [100]	Canada	160	Clinical Assessment	Se 32.0% Sp 85.0%	Criterion Validity
Council on Nutrition Appetite Questionnaire (CNAQ)	Hanisah (2012) [101]	Malaysia	145	SGA	Se 80.9% Sp 23.2% PPV 62.6% NPV 43.3% Cronbach's a = 0.546	Criterion Validity
Chinese Nutrition Screen (CNS)	Woo (2005) [99]	China	867	Clinical Assessment	k = 0.5 PPV 60.0% NPV 90.0% AUC 0.79	Criterion Validity
Eating Validation Scheme (EVS)	Beck (2013) [102]	Denmark	N/A	16 RCT's	Se 71.0% Sp 14.0% PPV 46.0% NPV 33.0%	Criterion Validity
Icelandic NST	Thorsdottir (2005) [103]	Iceland	60	Clinical Assessment	Se 89.0% Sp 60.0% PPV 76.0% NPV 79.0%	Criterion Validity
Nursing Nutrition Screening Assessment (NNSA)	Pattison (1999) [104]	Scotland	66	Clinical Assessment	No correlation was found between nurses and dietician k < 0.6	Construct Validity
Nutritional Risk Assessment Scale (NURAS)	Nikolaus (1995) [105]	Germany	126	Clinical Assessment	p < 0.05	Construct Validity
Rapid Screen (RS)	Young (2013) [39]	Australia	133	SGA	Se 29.0% Sp 100% PPV 100% NPV 62.1%	Criterion Validity
Rapid Screen (RS)	Young (2013) [39]	Australia	133	MNA-FF	Se 20.0% Sp 100% PPV 100% NPV 37.4%	Criterion Validity
Not Designed for Older Adults						
Community						
Maastricht Index (MI)	Naber (1997) [106]	The Netherlands	34	NRI	Limited use in the elderly	Construct Validity
Nutritional Risk Assessment Tool (NRAT)	Ward (1998) [107]	UK	507	Clinical Assessment	PPV 94.6% NPV 81.1%	Criterion Validity
Rehabilitation						
Simplified Nutritional Appetite Questionnaire (SNAQ-US)	Yaxely (2015) [48]	Australia	185	MNA-FF	Se 28.0% Sp 94.0% PPV 89.0% NPV 44.0%	Criterion Validity
Hospital						
Canadian NST	LaPorte (2015) [93]	Canada	150	SGA	Se 72.9% Sp 85.9% PPV 82.7% NPV 77.5%	Criterion Validity
Minimal Eating Observation Form-version 2 (MEONF-II)	Vallén (2011) [108]	Sweden	100	MNA-FF	Se 73.0% Sp 88.0% PPV 81.0% NPV 82.0%	Criterion Validity
Simplified Nutritional Appetite Questionnaire (SNAQ-US)	Hanisah (2012) [101]	Malaysia	145	SGA	Se 69.7% Sp 62.5% PPV 74.7% NPV 56.45% Cronbach's a = 0.578	Criterion Validity
Simple NST	Mayasari (2014) [109]	Indonesia	268	MNA-SF	Se 88.3% Sp 95.2 PPV 98.4% NPV 77.1%	Criterion Validity

AHSP: Appetite Hunger and Sensory Perception Questionnaire, AUC: Area under the Curve, k: Kappa Value, MNA-FF: Mini Nutritional Assessment Full Form, MNA-SF: Mini Nutritional Assessment Short Form, NPV: Negative Predictive Value, NRI: Nutrition Risk Initiative, NST: Nutritional Screening Tool, p: p-value, PPV: Positive Predictive Value, r: Correlation Co-efficient, RCT: Randomised Control Trial, Se: Sensitivity, SGA: Subjective Global Assessment, Sp: Specificity.

and/or validated in European and non-European population. Many tools designed outside Europe for use in the settings under review contain similar parameters to European tools. Furthermore, the diversity in ethnicity across Europe warrants the inclusion of these tools. Validation studies of tools in the hospital setting which focused on older adults in a particular disease group were excluded, as the purpose of this review was to review screening in the hospital setting as a whole, and not particular patient groups.

A difficulty with all validation studies is the criterion against which the tool is compared. In the absence of a gold standard reference, we used clinical assessment by a nutritionally trained professional, SGA or MNA-FF as our 'semi-gold standards'. Until we have consensus on a gold standard malnutrition assessment method, this is a limitation applicable to all reviews of malnutrition screening tools. Furthermore, although organisations such as ESPEN and the American Society for Parenteral and Enteral Nutrition (ASPEN) have recently published definitions of malnutrition [4,123], discrepancies between these definitions are apparent. The development of a global consensus on a gold standard definition of malnutrition should be a priority to allow future validation studies of malnutrition screening tools to be appropriately conducted.

Another concern which emerged from this literature review was the inconsistency between the terms 'nutritional screening tool' and 'malnutrition screening tool'. Tools which are used to screen for risk of malnutrition are most often referred to as nutritional screening tools (NSTs) in the literature; however, this can potentially create confusion. Perhaps a change of terminology is needed when referring to screening for risk of malnutrition.

Tools with the greatest evidence of validity (validation study design and results), appear to be MUST and MST (in hospitals), SCREEN-II (in the community), SNAQ^{RC} (in residential care) and NUFFE (in rehabilitation). Poor study design (tools not compared to an appropriate reference standard) and weak validation results (e.g. low sensitivity and specificity) were evident in many of the validation studies identified in this review. For the majority of malnutrition screening tools, more high quality studies are needed before definitive conclusions on their validity can be made. Although this review aimed to critically review validation studies, reliability should also be considered in future reviews given its importance in determining a tools performance in a real life setting. Moreover, other aspects of screening tools, such as practicability and the parameters which the tool measures, need to be considered in conjunction with validity, to decide which tools are the most appropriate to use with older adults in community and healthcare settings.

Greater focus has been given to screening in the hospital setting compared to other healthcare settings. While concern for nutritional status is vital in this setting due to illness or injury, older adults are also at risk of deteriorating nutritional status in settings other than in hospital. For this reason, increased attention to malnutrition screening of older adults in settings outside of hospital is needed. While several tools have been developed for community-dwelling older adults, more studies are needed to justify their use. Only one tool has been specifically developed for nursing home residents, and one for older rehabilitation patients; however, some tools which were designed for other settings have demonstrated good validity in these settings; therefore, the creation of additional tools for these settings is not warranted.

Conclusion

After a thorough critical review of the validity of malnutrition screening tools in older adults, it became apparent that due to poor validation study design and results, it is insufficient to make recommendations for malnutrition screening based on current validation evidence alone. Although the validation of malnutrition screening tools in older populations requires further work, it is important to acknowledge the work carried out to date and its positive impact on malnutrition screening, particularly in the older population. It is anticipated that the results from the JPI HDHL MaNuEL Knowledge Hub will strengthen evidence-based practise in the management of malnutrition in older adults. A subsequent study which aims to develop and apply a scoring system to rate tools based on validation, together with the suitability of the tools parameters for screening older adults and the tools practicability, will contribute to the identification of preferred malnutrition screening tools and harmonisation of malnutrition screening research and clinical practise across Europe and internationally.

Conflict of interest

None to declare.

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